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EFFECTS OF BOILING PARAMETERS ON THE LEVELS OF NITRATE, NITRITE AND COLOR VALUES OF WILD RADISH (*Raphanus raphanistrum*)

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Abstract

Wild radish (*Raphanus raphanistrum*) is commonly consumed as a salad or an ingredient in some recipes. The increasing levels of nitrate and nitrite concentrations are becoming an important problem for public health. Wild radish is known to have significant portion of nitrate. It is generally consumed after boiling. For these reasons it is important to determine nitrate and nitrite contents of fresh and boiled wild radish samples. In this study, the effects of boiling on the levels of nitrate, nitrite and color values of 10 wild radish samples purchased from open markets in Izmir, were reported. All of the fresh samples contained higher amounts of nitrate than nitrite. Nitrate concentrations in samples which were boiled with less amount of water decreased after 7.5 minutes boiling but increased after 15 minutes boiling. Nitrate concentration in samples, which were boiled with much water, decreased by boiling time. Statistically significant correlations were obtained between nitrate, nitrite contents and L*, a*, b* values.

Keywords: Nitrate, nitrite, L*, a*, b*, wild radish

HAŞLAMA PARAMETRELERİNİN TURP OTUNUN (*Raphanus raphanistrum*) NİTRAT, NİTRİT DÜZEYLERİ VE RENK DEĞERLERİ ÜZERİNE ETKİLERİ

Özet

Turp otu (*Raphanus raphanistrum*) genel olarak salata olarak veya bazı tariflerde içerik olarak kullanılmaktadır. Nitrat ve nitrit konsantrasyonlarının artan seviyeleri, toplum sağlığı açısından önemli bir problem oluşturmaktadır. Turp otunun önemli düzeyde nitrat içerdiği bilinmektedir. Turp otu genellikle haşlandıktan sonra tüketilmektedir. Bu nedenlerden dolayı taze ve haşlanmış turp otu örneklerinin nitrat ve nitrit içeriklerinin belirlenmesi önemlidir. Bu çalışmada İzmir'de pazar yerlerinde satılan 10 farklı turp otu örneğinin nitrat, nitrit düzeyleri ve renk değerleri üzerine haşlamanın etkileri rapor edilmiştir. Tüm taze örneklerin nitrat içeriği, nitrit içeriğinden yüksek bulunmuştur. Az miktarda suyla haşlanan örneklerin nitrat içeriği 7.5 dk haşlamadan sonra azalmıştır fakat 15 dk haşlamadan sonra artış göstermiştir. Daha fazla miktarda suyla haşlanan örneklerin nitrat içeriği haşlama süresi ile azalmıştır. Nitrat, nitrit içerikleri ve L*, a*, b* değerleri arasında istatistiksel olarak önemli korelasyonlar elde edilmiştir.

Anahtar kelimeler: Nitrat, nitrit, L*, a*, b*, turp otu

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INTRODUCTION

Edible wild and culture plants are found in countries with rather varied climates. Plant greens and seeds were important foods in the traditional diet of the first European farmers. They consumed plants that today are no longer generally considered for nutrition. Some modern culture still consume wild plants as a normal food source, obtaining fairly good amounts of several nutrients, and it is widely accepted that leafy green vegetables are significant nutritional sources of minerals. The main contrast for the nutritional exploitation of these plants is the presence of certain anti-nutritional and toxic substances such as nitrate, oxalate and saponin (1). In the Aegean region of Turkey, a plateful of raw or cooked vegetables commonly precedes the main meal. Wild radish (*Raphanus raphanistrum*) is classed as leafy vegetable and botanically it belongs to family, namely *Cruciferae*. The main consumption form of wild radish is boiled and then mixed with olive oil, garlic, lemon juice or yoghurt. It is available to purchase from the open market and to pick from nature. It is picked in spring before the flowers appear. This vegetable is characterized by high nutritive value. It contains considerable amount of vitamins (2). Unfortunately, as in other leafy vegetables, wild radish shows a tendency to accumulate compounds unwanted in human diet, like nitrates and nitrites (3). Human nitrate intake is mainly from vegetables, water supplies and from additives/preservatives used in meat (4).

Nitrates form part of the essential chemistry of soils and plants. Thus plant roots are able to absorb nitrate directly from the soil. Nitrate contamination in vegetables occurs when crops absorb more than they require for their sustainable growth (4). Leafy vegetables potentially disposed to accumulate excessive amounts of nitrates. The content of nitrate and nitrite depends on the plant species, cultivar, level and type of fertilization, light conditions, temperature, humidity and structure of the soil, and even the application of plant protection agents (3).

The nitrates in foods can be reduced to nitrite. It is known that nitrite causes methemoglobinemia and, with secondary and tertiary amines, yields the carcinogenic nitrosamines (3). Highly carcinogenic N-nitrosamines could be formed by the reaction of nitrite with secondary amines and amides, which are generally present in food items, such as meat and fish, where nitrite is used as a food preservative (5). Concern over nitrite intakes originates from the fact they are implicated in the genesis of some forms of cancer and methemoglobinemia, although it is suggested that nitrite ions play a beneficial role in the generation of the physiologically important nitrite oxide (6). The determination of nitrite is of general importance because of its harmful impact on human health (7).

It was estimated that 80% of human cancers were caused by environmental factors associated with food, water and air (8). High dietary intakes of nitrate and nitrite have been implicated in the etiology of human gastric cancer based on epidemiology and clinical studies. The dietary intake of nitrates and nitrites in foods can vary greatly from region to region depending on factors such as farming practices, climate, soil quality, manufacturing processes and legislation (9).

Technological measures in vegetable processing, such as washing, blanching, shredding, freezing, or canning, can contribute to changes in the nutritional value, including the level of unwanted compounds. Processing with the use of water (washing, blanching) usually reduces the content of nitrates and nitrites (10, 11). Nitrate concentrations in vegetables vary enormously. Even amongst different samples of the same variety of vegetables, the range of nitrate concentration can be very large. Nitrite contents of processed or even frozen vegetables can be two to threefold greater than those of their unprocessed counterparts (12). In vegetables that need to be cooked, the effect of the boiling is of concern (9). The color of vegetables is of importance from the consumer point of view. The color of any food is expressed by L* (lightness), a* (greenness), b* (yellowness) in CIE system (13).

Plant foods will become increasingly important. In this respect, future research needs to concentrate on the integration of natural plant foods that are known or commonly consumed in various countries or cultures. The aim of this study was to determine the effects of boiling, boiling time, water amount used for boiling on the levels of nitrates, nitrites and color parameters in wild radish samples grown in the Aegean Region of Turkey.

MATERIALS AND METHODS

Materials

Samples

All samples were grown in the open field and purchased from local markets in Izmir from February to April. One kilogram of each vegetable packed in a polyethylene bag was purchased. Edible parts of vegetables were assayed, and disease infected plants or leaves were discarded. All vegetables were kept at refrigeration temperature. The wild radish samples were boiled without using salt, in stainless-steel pots, until ready for consumption for 7.5 and 15 minutes, at the temperature of around 100 °C. Each boiling process was repeated three times. Nitrate and nitrite contents of 10 samples were determined, each of them in triplicate. Color of 10 samples were determined, each of them in triplicate. Four of the samples were boiled with 250 ml water (less water), six of the samples were boiled with 500 ml water (much water). Sample amount was 200 g for both boiling procedure.

Reagents

Analytical grade reagents were used. Sodium nitrite, sodium nitrate, cadmium acetate dihydrate, sulfanilic acid, N-(1-naphthyl)-ethylenediamine dihydrochloride, glacial acetic acid, ammonia, potassium ferrocyanide trihidrate and disodium tetraborate decahydrate were purchased from Merck (Darmstadt, Germany). Zinc sulfate heptahydrate was purchased from Riedel-de Haën (Seeize, Germany) and zinc powder from BDH (Poole, U.K.). Distilled water used throughout the procedure was supplied from the distillation apparatus of Hamilton Laboratory Glass Limited (Margate Kent, U.K.).

Methods

Sample preparation

The procedure of Özdestan & Üren (14) was followed. Hot water was used for extraction. Extract was immediately analyzed. The same extract was used for both nitrate and nitrite analyses.

Nitrate analysis by spectrophotometric method

Nitrate analysis was achieved according to Özdestan & Üren (14). The principles of the method were the reduction of nitrate to nitrite with cadmium and the colorimetric determination of nitrite with Griess reagent. Absorbance was read at 538 nm against a reagent blank using a spectrophotometer (Cary 50 UV-vis, Varian, UK).

Nitrite analysis by spectrophotometric method

To determine nitrite contents of samples, the method of Özdestan & Üren (14) was used. To determine the nitrite content of samples, a 0.5 ml aliquot of sample extract was diluted to 50 ml with distilled water. Eight mililiters of sample was added to both 1 ml of glacial acetic acid and to 1 ml of Griess reagent. Nitrate in the samples was determined by subtraction of the measured nitrite value from that of the cadmium-reduced extract.

Color measurement

CIE L*, a* and b* values of wild radish samples were determined with Hunter colorimeter. Color measurements of the wild radish samples were carried out using a Hunter Lab Color flex (CFLX 45-2 Model Colorimeter, Hunter Lab, Reston, VA). The instrument was standardized each time with a black glass and a white tile. The color values were expressed as L*, a*, and b* at any time. Color value, L*, indicates how brightness/darkness the sample is (varying from 0 black to 100 white), a* is a measure of greenness/redness (varying from 60 to 60), and b* is the grade of blueness/yellowness (also varying from 60 to 60).

Apparatus

Absorbance of the red-violet azo compound was measured with a Cary 50 UV-vis spectrophotometer (Varian, U.K.). To determine CIE L*, a* and b* values, Hunter colorimeter was used (Hunter Lab, Reston, VA).

Statistical analysis

All of the statistical analyses were performed with the SPSS 15.0 statistics package program. Statistical analysis of data was performed using a one-way analysis of variance (ANOVA), Duncan post-test, paired t test and Pearson correlation test. In all data analyses, a value of $P < 0.05$ was considered as statistically significant.

RESULTS AND DISCUSSION

Fresh wild radish samples

Table 1 shows the levels of nitrates and nitrites in the fresh analyzed samples. As was expected, significant differences between some samples grown under different conditions can be observed. As seen in the Table 1, the highest average nitrate values for fresh samples were obtained for WR2 (2981.5 mg/kg) and the lowest average nitrate values were obtained for WR8 (249.9 mg/kg). The highest average nitrite values for fresh samples were obtained for WR2 (18.2 mg/kg). The lowest average nitrite values were obtained for samples WR1, WR8 and WR9 (not detected). While nitrate contents were high for fresh samples in most cases, nitrite contents were low. Average nitrate concentration of 1831.7 mg/kg for fresh wild radish samples was detected. Average nitrite concentration of 7.2 mg/kg for fresh wild radish samples was detected.

Table 1. Nitrate and nitrite contents (mg/kg) and standard deviation values of fresh wild radish samples[a]

Sample code	Nitrate	Nitrite
WR1*	2554^{b}±222	ND
WR2*	2982^{a}±130	18.2^{a}±3.6
WR3*	711^{g}±84	11.1^{ab}±19
WR4*	1040^{ef}±47	3.7^{b}±2.4
WR5	1497^{c}±278	5.1^{b}±4.1
WR6	1416^{cd}±36	1.6^{b}±0.6
WR7	867^{fg}±68	3.4^{b}±1.0
WR8	250^{h}±31	ND
WR9	1256^{de}±34	ND
WR10	1191^{de}±95	6.6^{b}±0.8

[a]ND=not detected. Different matching letters in a column mean significant differences according to Duncan test ($P < 0.05$)
*samples boiled with 250 ml water (less water)

An accurate, fast, easily applicable, and cost-effective method for the determination of nitrate and nitrite was developed by Özdestan & Üren (14). Nitrate and nitrite contents of 10 types of leafy vegetables native to the Aegean region of Turkey were determined. According to the results of Özdestan & Üren (14), among the leafy vegetables tested, wild radish had the highest nitrate content, whereas chicory, blessed thistle, spinach, lettuce, and iceberg lettuce had the lowest ($P < 0.05$). Nitrate contents of wild radish samples ranged from 3544 to 5764 mg/kg with the mean value of 4653 mg/kg. Nitrite contents of wild radish samples ranged from non detectable values to 0.40 ppm with the mean value of 0.13 ppm. The reason of differences between the nitrate and nitrite content of wild radish samples was different harvest time and growing conditions. When the overall mean values for nitrate and nitrite were compared (Table 1), no significant correlation was detected between nitrate and nitrite contents of the green leafy vegetables tested. Likewise, Amr & Hadidi (6) and Özdestan & Üren (14) did not find any correlations between nitrate and nitrite contents of vegetables grown in the open field.

Statistically significant differences were also detected between the samples belonging to the same type, as the harvest time, growing conditions, farming practices, climate, soil quality, level and type of fertilization, and other factors affect the nitrate and nitrite contents of vegetables ($P < 0.05$). These findings correlated well with the literature. Hsu et al. (9) quantified nitrate and nitrite contents of a range of vegetables. It was demonstrated that nitrate contents ranged from 48.0 to 4849.6 mg/kg and nitrite contents varied from non detectable values to 19.6 mg/kg. According to the results of Huarte-Mendicoa et al. (15), in none of the cases was the nitrite content over 1 ppm. Nitrate levels ranged from 48.9-97.1 ppm for broccoli samples.

L*, a* and b* values of fresh wild radish samples were given in Table 2. L* values of fresh wild radish samples changed from 28.3 to 43.3. a* values of fresh wild radish samples changed from -4.7 to -10.7. b* values of fresh wild radish samples changed from 14.1 to 25.3. Average L* values of 37.0 for fresh wild radish samples was detected. Average a* values of -8.2 for fresh wild radish samples was detected. Average b* values of 20.0 for fresh wild radish samples was detected. Statistically significant correlations were obtained between L* values and a* values; between L* values and b* values; a* values and b* values for fresh samples ($P < 0.05$). Significant negative correlations were obtained between L* values and nitrate contents; between a* values and nitrate contents; between b* values and nitrate contents; between b* values and nitrite contents for fresh samples ($P < 0.05$).

Table 2. Mean L*, a*, b* values and standard deviation values of fresh wild radish samples

Sample code	L*	a*	b*
WR1	29.5±0.1	-4.7±0.1	20.7±0.1
WR2	28.3±0.2	-7.0±0.1	14.1±0.1
WR3	37.9±3.3	-8.4±0.4	19.5±1.9
WR4	40.5±4.3	-9.3±0.9	22.0±2.2
WR5	40.6±0.2	-8.2±0.1	22.5±0
WR6	36.3±0.1	-10.7±0.1	23.3±0.1
WR7	36.7±0.9	-8.0±0.3	17.4±0.8
WR8	43.3±2.5	-8.9±0.4	25.3±4.1
WR9	37.3±1.7	-8.6±1.0	17.9±1.2
WR10	39.3±2.9	-8.1±0.5	17.1±3.3

Boiled wild radish samples

Table 3 shows the levels of nitrates and nitrites in the boiled analyzed samples. When compared nitrate values of wild radish samples boiled with 250 ml water (less water), there were significantly important differences between samples ($P < 0.05$). Average nitrate content of 7.5 minutes boiled samples was 826 mg/kg. Average nitrate content of 15 minutes boiled samples was 1584 mg/kg. When compared nitrite values of wild radish samples boiled with 250 ml water, there were not significantly important differences between samples ($P < 0.05$). Average nitrite content of 7.5 minutes boiled samples was 3.5 mg/kg. Average nitrite content of 15 minutes boiled samples was 11.9 mg/kg. According to Pearson correlation test ($P < 0.05$) statistically significant correlations were obtained between nitrate concentrations of wild radish samples boiled with less water. Statistically significant correlations were obtained between 7.5 minutes boiled samples and 15 minutes boiled samples; between fresh samples and 7.5 minutes boiled samples; between fresh samples and 15 minutes boiled samples ($P < 0.05$). According to Pearson correlation test ($P < 0.05$), statistically significant correlations were obtained between nitrite concentrations of wild radish samples boiled with less water. Statistically significant correlations were obtained between 7.5 minutes boiled samples and 15 minutes boiled samples ($P < 0.05$). No statistically significant correlations were detected between fresh samples and 7.5 minutes boiled samples; between fresh samples and 15 minutes boiled samples ($P < 0.05$).

Nitrate contents of fresh wild radish samples were compared with boiled wild radish samples by using the paired t test. Significant differences were detected between fresh samples and 7.5 minutes boiled samples; between 7.5 minutes boiled samples and 15 minutes boiled samples ($P < 0.05$). Nitrate contents of fresh wild radish samples were higher than 7.5 minutes boiled samples. Nitrate contents of 15 minutes boiled samples were higher than 7.5 minutes boiled samples. No significant differences were detected between fresh samples and 15 minutes boiled samples ($P < 0.05$). Nitrite contents fresh wild radish samples were compared with boiled wild radish samples by using the paired t test. No significant differences were detected between

Table 3. Nitrate and nitrite contents (mg/kg) and standard deviation values of boiled wild radish samples[a]

Sample code	Nitrate		Nitrite	
	7.5 minutes boiled samples	15 minutes boiled samples	7.5 minutes boiled samples	15 minutes boiled samples
WR1*	1394^{a}±139	2858^{a}±201	ND	ND
WR2*	1033^{b}±95	1954^{b}±102	9.9^{a}±1.3	31.5^{a}±10.5
WR3*	632^{c}±35	1065^{c}±110	0.2^{c}±0.2	6.0^{cd}±0.6
WR4*	248^{e}±12	462^{d}±64	$3.9b^{c}$±3.2	10.3^{bc}±1.1
WR5	1169^{b}±176	982^{c}±149	6.4^{ab}±1.9	6.3^{cd}±2.5
WR6	546^{cd}±33	334^{d}±49	7.0^{ab}±0.6	3.9^{cd}±0.9
WR7	568^{c}±52	484^{d}±106	6.1^{ab}±0.8	15.0^{b}±3.6
WR8	103^{f}±44	72^{e}±12	ND	ND
WR9	555^{cd}±5	509^{d}±10	9.1^{a}±6.1	1.9^{d}±1.6
WR10	413^{d}±28	342^{d}±63	0.4^{c}±1.2	0.8^{d}±0.7

[a]ND=not detected. Different matching letters in a column mean significant differences according to Duncan test ($P < 0.05$)
*samples boiled with 250 ml water (less water)

fresh samples and 7.5 minutes boiled samples; between fresh samples and 15 minutes boiled samples ($P < 0.05$). Significant differences were detected between 7.5 minutes boiled samples and 15 minutes boiled samples. Nitrite contents of 15 minutes boiled samples were higher than 7.5 minutes boiled samples.

When compared nitrate values of wild radish samples boiled with 500 ml water (much water), statistically significant differences were obtained between samples ($P < 0.05$). When compared nitrite values of wild radish samples boiled with 500 ml water, no statistically significant differences were detected between samples ($P < 0.05$). Average nitrate content of 7.5 minutes boiled samples was 558 mg/kg. Average nitrate content of 15 minutes boiled samples was 453 mg/kg.

According to the results of Pearson correlation test, significant correlations were obtained between nitrate concentrations of wild radish samples boiled with much water. There were statistically significant correlations between fresh samples, 7.5 minutes boiled samples and 15 minutes boiled samples ($P < 0.05$). Statistically significant correlations were obtained between fresh samples and 7.5 minutes boiled samples. Statistically significant correlations were obtained between fresh samples and 15 minutes boiled samples. According to the results of Pearson correlation test, no significant correlations were obtained between nitrite concentrations of wild radish samples boiled with much water ($P < 0.05$).

Nitrate contents of fresh wild radish samples were compared with boiled wild radish samples by using the paired t test. Significant differences were detected between fresh samples and 7.5 minutes boiled samples; between fresh samples and 15 minutes boiled samples; between 7.5 minutes boiled samples and 15 minutes boiled samples ($P < 0.05$). Nitrate contents of fresh wild radish samples were higher than 7.5 minutes boiled samples and 15 minutes boiled samples ($P < 0.05$). Average nitrite content of 7.5 minutes boiled samples was 4.8 mg/kg. Average nitrite content of 15 minutes boiled samples was 4.6 mg/kg. Nitrite contents of fresh wild radish samples were compared with boiled wild radish samples by using the paired t test. No significant differences were detected between fresh samples and 7.5 minutes boiled samples; between fresh samples and 15 minutes boiled samples; between 7.5 minutes boiled samples and 15 minutes boiled samples ($P < 0.05$).

L*, a* and b* values of boiled samples were given in Table 4. L* values of 7.5 minutes boiled samples changed from 22.8 to 34.4, a* values of 7.5 minutes boiled samples changed from -5.0 to -12.2. b* values of 7.5 minutes boiled samples changed from 20.0 to 27.5. Average L* values of 29.9 for 7.5 minutes boiled samples was detected. Average a* values of -8.9 for 7.5 minutes boiled samples was detected. Average b* values of 23.8 for 7.5 minutes boiled samples was detected. L* values of 15 minutes boiled samples changed from 18.0 to 31.3, a* values of 15 minutes boiled samples changed from -2.2 to -9.4, b* values of 15 minutes boiled samples changed from 13.5 to 28.1. Average L* values of 25.8 for 15 minutes boiled samples was detected. Average a* values of -6.5 for 15 minutes boiled samples was detected. Average b* values of 20.9 for 15 minutes boiled samples was detected. Statistically significant correlations were detected between L* values and b* values for 7.5 minutes boiled sample ($P < 0.05$). Statistically significant negative correlations were detected between L* values and nitrate contents for 7.5 minutes boiled sample ($P < 0.05$). Statistically significant correlations were detected between L* values and a* values; between L* values and b* values for 15 minutes boiled sample ($P < 0.05$). Negative correlations were detected between L* values and nitrate contents; between L* values and nitrite contents; between a* values and nitrate contents for 15 minutes boiled sample ($P < 0.05$). Lightness (L*) of samples decreased by boiling, greenness (a*) increased in first 7.5 minutes then decreased by time. Yellowness (b*) increased in first 7.5 minutes then decreased by time. According to the results of paired t test, no significant differences were detected between L* values, a* values and b* values of fresh, 7.5 minutes boiled samples and 15 minutes boiled samples.

According to the results of our study, boiling time and especially water amount used in boiling affect nitrate content of samples. Wild radish samples, which were boiled with less amount of water, nitrate concentration decreased by 7.5 minutes boiling but increased by 15 minutes boiling. Water amount decreased by 15 minutes

Table 4. Mean L*, a*, b* values and standard deviation values of boiled wild radish samples

Sample code	7.5 minutes boiled samples			15 minutes boiled samples		
	L*	a*	b*	L*	a*	b*
WR1	27.7±0.1	-7.0±0.1	25.9±0.1	22.2±0.1	-2.2±0	25.2±0.1
WR2	27.5±0.1	-7.5±0.1	21.8±0.1	18.0±0.1	-4.6±0.1	20.6±0.1
WR3	32.2±1.1	-9.1±2.1	26.4±0.4	29.6±2.2	-7.3±0.9	25.2±1.6
WR4	34.4±6.4	-11.5±0.7	25.9±4.7	28.7±1.0	-9.4±0.6	13.5±2.3
WR5	30.0±0.2	-8.3±0.1	21.9±0.2	29.0±0.2	-6.0±0.1	18.8±0.1
WR6	22.8±0.1	-11.7±0.1	21.6±0.2	22.6±0.1	-7.9±0.1	19.1±0.2
WR7	29.4±1.3	-6.8±0.1	20.3±3.1	25.1±1.0	-4.5±0.2	18.6±1.0
WR8	34.0±2.5	-5.0±0.8	27.5±1.7	31.3±1.9	-6.3±3.1	28.1±1.0
WR9	33.0±3.6	-12.2±0.5	26.4±1.6	27.5±1.2	-8.5±0.4	21.3±3.7
WR10	27.5±1.2	-9.9±1.1	20.0±2.3	24.4±0.8	-7.8±1.5	18.9±2.1

boiling so nitrate concentration increased. If the amount of water was adequate, nitrate concentration decreased by the time because nitrate was soluble in water. All of the samples' nitrate concentration found higher than nitrite concentration. The changes in nitrite level were irregular for both boiling methods.

Comparison of literature data

Boiling reduces nitrate-N content since nitrate-N is soluble and predisposed to readily leach into the cooking liquids (15). It is evident that the nitrate-N values are significantly reduced and similar observation is reported in literature (16). In comparison with two minutes blanching, the cooking of the raw material for four minutes before preservation contributed to a distinctly greater decrease in the content of the analyzed compounds by Jaworska (10).

Leszczynska et al. (17) analyzed to determine changes in nitrate and nitrite content in selected cruciferous vegetables, resulting from blanching, boiling, freezing, frozen storage and boiling after previous freezing. Both blanching and boiling of the cruciferous vegetables caused a considerable decrease in the total nitrate content, but at the same time no explicit changes were noted regarding the level of nitrite. These findings were correlated with our results. According to Czarniecka et al. (18) boiling of Brussels sprouts (starting with boiling water) causes nitrite increase by 84%. Similar effect of the traditional boiling of broccoli on the content of the discussed compounds (only 9% increase) was reported by Kmiecik & Budnik (19). The literature references contain information about the reduction of nitrite during the processing techniques that we analyzed in other vegetables as well. Lutsoya & Rooma (20) shared the opinion that a considerable quantity of nitrite contained in the vegetables was retained in the boiling water. The level of nitrate and nitrite content in raw plant material is not in direct proportion to their actual uptake, as both initial handling of the vegetables (washing and peeling) and cooking techniques may affect the final levels these compounds.

CONCLUSION

Nitrate contents of fresh wild radish samples changed between 710.5 and 2981.5 mg/kg. Nitrite contents of fresh wild radish samples changed from non detectable values to 18.2 mg/kg. All of the fresh samples contained higher amount of nitrate than nitrite. Boiling time and water amount used in boiling affected nitrate contents of samples. Samples boiled with less water nitrate content decreased after 7.5 minutes but increased after 15 minutes boiling. Samples boiled with much water nitrate content decreased by boiling time. The changes in nitrite level were irregular for both boiling methods. L* values of fresh wild radish samples changed from 28.3 to 43.3. a* values of fresh wild radish samples changed from -4.7 to -10.7. b* values of fresh wild radish samples changed from 14.1 to 25.3. L* values of samples decreased by boiling, a* values increased in first 7.5 minutes then decreased by time. b* values increased in first 7.5 minutes then decreased by time. Statistically significant correlations were obtained between nitrate, nitrite contents and L*, a*, b* values.

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